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Theoretical investigation of proton exchange membrane fuel cells oriented to automotive applications

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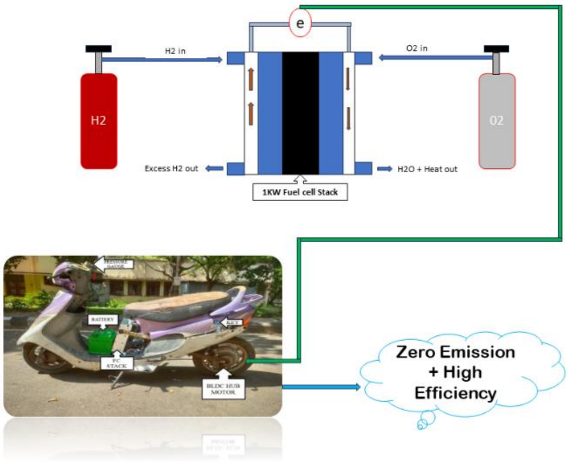
Graphical abstract



Abstract

This research discusses the potential of proton exchange membrane fuel cells (PEMFCs) as a renewable energy source due to their efficiency and low environmental impact. The study uses MATLAB simulations and theoretical analysis to understand PEMFC behaviour. It reveals that as the load increases, so does the fuel flow rate, as more fuel is required to generate the same amount of power. The study also examines the viability of PEMFCs for electric cars and their response to mechanical strain. This study concludes that as the load increases, the fuel flow rate also increases, as the interaction between fuel and oxygen produces power. This relationship between the two variables is also noted under certain circumstances. For a light-weight delivery truck operating at a top speed of 28.8 km/h, a 1KW stack is sufficient. Simulated H2 consumption is 9.89 g of H2 to cover 569m in 108 s at a maximum speed of 28.8 km/hr. Fuel cell bikes are a promising alternative to traditional motorcycles in urban areas due to their reduced pollution and quick fuel refill capabilities. They compete with IC engine vehicles for greater range and emission-free capabilities.

Keywords: Fuel cells, electrodes, membrane, cell voltage, current density

1. Introduction

Fuel cell bikes have become an essential technology for the utilization of hydrogen and will definitely have a significant impact on the growth and change of the automotive sector. The development of fuel cell bikes has several benefits, including cost-effective energy savings, robust power outputs, safety, and dependability. It probably examines how PEM fuel cells work under various loads, maybe adjusting the electrical demand or operating parameters to see how these modifications impact the fuel cell's output, efficiency, and overall performance. Understanding how varied loads affect PEM fuel cell functioning may help optimize fuel cell operations for a range of real-world applications (Sahu *et al*. 2014; Bizon, 2014; Martín *et al*. 2014; Zhang *et al*. 2019). Huseyin Devrim at al, study explores the feasibility, economy, and utility of PEM fuel cells as portable generator power sources, offering new insights into fuel cell technology for mobile energy applications (Devrim *et al*. 2015; Tori *et al*. 2008). A more thorough knowledge of the internal processes taking place within PEM fuel cells is likely the reason behind the development of the dimensional model, which takes into consideration a number of essential characteristics like heat transfer, reactant flow, electrochemical reactions, and other aspects that impact performance.

The goal of this study is probably to improve fuel cell behaviour predictability and accuracy, which will develop PEM fuel cell technology and its useful applications (Zhu and Li, 2010; Genre-Grandpierre *et al*. 2008; Piumsomboon *et al*. 2013; Muthukumar *et al*. 2021). In order to better understand and manage the behaviour of proton exchange membrane (PEM) fuel cells in real-world applications and to progress fuel cell technology, the study attempts to create and evaluate mathematical models for PEM fuel cells (Mu *et al*. 2012; Amphlett *et al*. 1995; Saygılı *et al*. 2015; Bizon 2014). Wu, Peng, Yin, *et al*.'s work, "Review of System Integration and Control of Proton Exchange Membrane Fuel Cells," offers a thorough examination of PEM fuel cell system integration and control techniques. In order to improve performance, dependability, and application across a range of sectors, it addresses power management, thermal management,

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control algorithms, and system optimization (Abd El Monem *et al*. 2014; Wu *et al*. 2014).

This study investigates the impact of temperature variations on proton exchange membrane (PEM) fuel cell performance. It examines various temperature ranges and their effects on reactant kinetics, heat management, and electrochemical reactions. The ultimate goal is to provide a comprehensive understanding of temperature's influence on PEM fuel cell behaviour, aiming to maximize efficiency and performance under different operating conditions (Esfeh and Hamid, 2014; Aquino and Heng, 2017). It addresses a feedback parameter—stack voltage measurements—for controlling the air flow rate in a proton exchange membrane (PEM) fuel cell device. With an emphasis on the effects of stack voltage measurements, the goal is to optimize the control strategy in order to preserve ideal operating conditions and enhance the fuel cell system's overall performance (Vasu and Tangirala, 2008, Cruz Rojas *et al*. 2017; Bi *et al*. 2009).

The MATLAB Simulink models used to simulate the behaviour of PEM fuel cell stacks will be examined in this study. With an emphasis on reactant flow, heat transfer, and electrochemical processes, it will look at their components, structure, and characteristics. The goal is to pinpoint their advantages, disadvantages, and future directions for development in order to maximize their research and optimization of PEM fuel cell stack performance using computer simulations (Khan *et al*. 2013; Kuo *et al*. 2011; Campanari *et al*. 2009). To analyse the behaviour and effectiveness of the fuel cell system, a number of important performance parameters are usually evaluated in a MATLAB simulation model for proton exchange membrane fuel cells (PEMFCs). Several of these criteria consist of:

- **Cell Voltage:** The voltage generated by the fuel cell, which indicates its electrical output.
- **Current Density:** The current produced by the fuel cell per unit area, which is a measure of its power output.
- **Power Output:** The electrical power generated by the fuel cell, calculated as the product of cell voltage and current density.
- **Efficiency:** he efficiency of the fuel cell system, which is typically assessed in terms of the ratio of electrical power output to the input fuel energy.
- **Hydrogen and Oxygen utilization:** The utilization of hydrogen fuel and oxygen from the air within the fuel cell electrodes.
- **Water management:** Evaluation of the management of water produced within the fuel cell, as excessive water accumulation can affect its operation.
- **Dynamic Response:** Analysis of the transient response of the fuel cell system to changes in operating conditions or external loads.
- **Durability:** Evaluation of the long-term performance and degradation mechanisms of the fuel cell components, including the membrane, catalyst layers, and electrodes.

Understanding the behaviour of PEMFCs under various operating situations, optimizing their design, and enhancing their longevity and performance all depend on these factors. Through the use of MATLAB simulation models, scientists and engineers may thoroughly examine these factors and improve the layout and functionality of PEMFC systems.

Water quality, pressure, temperature, hydrogen content, and other variables all have a big impact on how effective proton exchange membrane fuel cells (PEMFCs) are. Based on studies and research, here are the ways in which each of these factors affects PEMFC performance:

- **Temperature:** Temperature affects the kinetics of the electrochemical reactions within the fuel cell. Higher temperatures generally increase reaction rates, leading to higher power output. However, excessively high temperatures can also accelerate degradation processes, reducing the durability of PEMFC components such as the membrane and catalyst layers. Therefore, maintaining an optimal operating temperature is crucial for balancing performance and durability in PEMFCs.
- **Pressure:** Pressure influences the transport of reactants (hydrogen and oxygen) within the fuel cell. Higher pressures can enhance mass transport, leading to improved reaction kinetics and higher power output. However, excessive pressure can also increase system complexity and cost. Therefore, an optimal pressure level needs to be determined based on performance and cost considerations.
- **Hydrogen Concentration:** Hydrogen concentration in the fuel supply directly affects the rate of hydrogen oxidation at the anode. Higher hydrogen concentrations typically lead to higher reaction rates and thus higher power output. However, operating at extremely high hydrogen concentrations can lead to issues such as hydrogen crossover and catalyst poisoning, impacting cell performance and durability.
- **Water quality:** Water quality, particularly in terms of purity and impurities, can impact the performance and durability of PEMFC components. Impurities in the feedwater can contaminate the catalyst layers, leading to catalyst degradation and reduced performance. Water management within the fuel cell is also critical. Excessive water accumulation can flood the electrodes, blocking reactant transport and reducing performance. On the other hand, insufficient water can lead to membrane dehydration, affecting proton conductivity and performance.

Because of their interdependence, these variables need to be carefully taken into account while designing, running, and optimizing PEMFC systems. The goal of research investigations is to comprehend the intricate relationships between these factors in order to enhance PEMFCs' overall efficacy, durability, and efficiency for a range of applications.

Several automobile manufacturers have incorporated fuel cell technology in their products and hence the fuel cell technology is a rapidly growing branch in the field of science. By altering different physical factors, such as temperature, flow rates for air and fuel, and partial pressure, we have examined and numerically assessed performance characteristics of a fuel cell with a proton exchange membrane in this study. A mathematical model of an electric a bicycle powered by a fuel cell and a series hybrid to charge the battery has also been created. The model's expanded range, energy usage, and power consumption are determined by utilizing fuel cells as a range extender.

2. Materials and methods

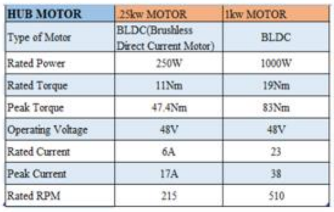
2.1. 1KW fuel cell stack

Figure 1 depicts a 1KW stack built using Horizon fuel cell technology with a rated voltage of 28.8V and a rated current of 35A. It is composed of plate-like cells with air passages to let air pass through the membrane. The membrane helps hydrogen flow through it, which releases electrons. Electrons may move between each pair of cells thanks to separator plates that carry electricity. The stack aspect involves stacking them on top of one another and holding them together with epoxy endplates.

Figure 1. 1KW stack

2.2. BLDC hub motor

BLDC is nothing but brush less DC motor by its name it says that absence of brushes in the motor for transferring the current so this will help to give maximum life time with noiseless and maintenance less motors. Here we have taken two motors based on power output from it. They are 250 watts motor and 1000 watts motor which as nominal torque output of 11Nm and 19 Nm respectively (Figure 2).



HUB MOTOR	.25kw MOTOR	1kw MOTOR
Type of Motor	BLDC(Brushless Direct Current Motor)	BLDC
Rated Power	250W	1000W
Rated Torque	11Nm	19Nm
Peak Torque	47.4Nm	83Nm
Operating Voltage	48V	48V
Rated Current	6A	23
Peak Current	17A	38
Rated RPM	215	510

Figure 2. Hub Motor with specifications

2.3. BLDC motor controller

Figure 3 BLDC motor controller is used to control the motor by getting signal from Hall Effect sensor present inside the motor. the motor can be started and stopped manually by selecting forward or backward rotation, controlling speed or torque, and safeguarding against overloads may all be included in a motor controller.

CONTROLLER	SPEC
Controller Type	BLDC Controller
Rated Voltage	48-60V
Rated Power	800-1000W
Maximum Current	30A
Phases Angle	120

Figure 3. BLDC motor controller with specifications

2.4. Hydrogen storage tank

The hydrogen storage tank is essential to the continuous power generation from the FC stack. Another factor is tank capacity, which shouldn't have an impact on the moped's standard design. Hydrogen is colourless, doorless, and flameless, making handling it more difficult with fewer alternatives for refuelling infrastructure and a higher danger. Therefore, after weighing all the options, I decided on a 2-kilogram commercial LPG cylinder. To turn it into a hydrogen storage cylinder, I connected a pressure gauge to check the internal pressure and report it to the driver (Figure 4).

Figure 4. H_2 storage tank

2.5. Key sets

Keys are helps to close circuit. An input voltage of 12v is required for the key to give input to the motor controller. This also acts as central locking system in the electric vehicle; if we want to close the circuit without key than every time, we need to connect it my manual wiring connection (Figure 5).

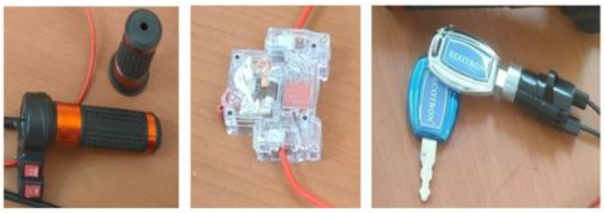


Figure 5. Key sets and throttle

2.6. Tank rig cage

Rig cage means a structure which can hold some compressive loading and to protect the component which it holds itself. Rib cage structure is similar with the rib cage present in every human body. To safeguard the hydrogen tank which is thin cylinder from unusual compressive loading we can use the rib cage structure.

There are 10 mm clearance are provided around the cylinder outer diameter which will be an addition helpful for the cylinder to keep protected (Figure 6).

Figure 6. Mild Steel Tank Rig

2.7. Battery

Battery is act as a storage medium for electric charge. We can carry battery anywhere as power source. Here, it helps for the fuel cell stack to begin by providing 12V (±1V) input voltage and 8A current. It acts as a starting system for two-wheeler (Figure 7).

Figure 7. Current storage

3. Experimental setup

Figure 8 shows to fabricate the two-wheeler, we use existing chassis of Baja maxima RE. Integrating the powertrain and rolling chassis conclude fabrication of vehicle. Powertrain include following components,

3.1. Fabrication of fuel cell Two-Wheeler

Fuel cell controller turn on the blower of the stack thus helps for oxygen consumption. It also controls h2 consumption in relation with power requirement and exhaust with help of purge valve.

1. Motor Controller: We use 40A, 48-60V rated controller for controlling motor. It helps in varying speed of motor and reversing its direction by regulating supply to coil of motor.
2. Contactor: Electrical circuits are protected from overloads and short circuits using MCB (Miniature Circuit Breaker) switches. In the event of a fault, it automatically interrupts the flow of electrical current to prevent harm to the circuit and electrical apparatus. MCB switches are compact, reliable, and widely used in residential, commercial, and industrial applications.
3. Battery:A 12V, 8A lead-acid battery is a rechargeable battery that most commonly used in automotive applications, backup power system and other low to moderate power requirement. Here battery is used to power the controller.
4. Motor:As we discussed above 48V, 3000RPM, 1 KW BLDC Motor of 10Nm torque is used to drive three-wheeler.

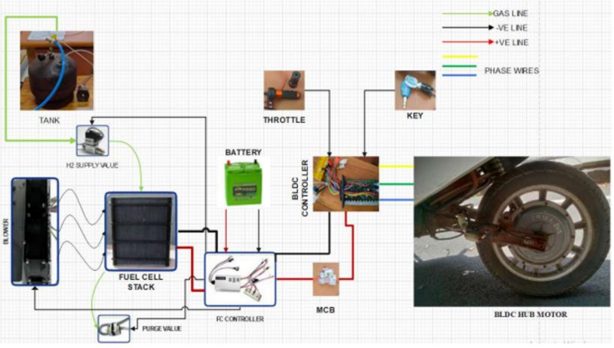


Figure 8. Electric Circuit for Fuel Cell Vehicle

By following the circuit all the connection was made. For the placement of the entire component in the vehicle chassis pre determination of component placement are planning using NX 8 software with all the need for Fuel cell stack are considered.

Figure 9 represented the motor is selected based on the power consumed by the motor from the fuel cell stack as well as the duration of run in the full throttle condition. Especially, how the fuel cell stack will meet the demand from the motor. The measuring of input current, input voltage, and hydrogen flow rate, a device called a programmable controller is used. The time duration is important for all the above parameters.

Figure 9. Fabricated Fuel Cell Based Two-Wheeler

3.2. Simulation setup

The power train is the separate system of the vehicle, the simulation dealt here is the model-based system simulation. Power train design and performance test developed based on this method is called Model Based System Engineering (MBSE). Figure 10 shows us the AVL cruise model is configured in accordance with the information about the power train architecture acquired through the benchmarking. The complete vehicle 37 1D model is modelled. The power train performance is obtained at the rear wheel and the braking is obtained with the help of the front wheel.

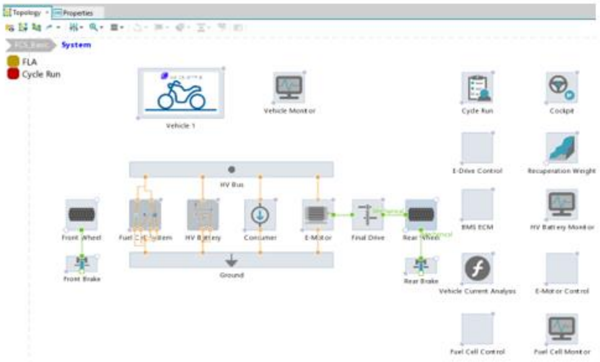


Figure 10. Vehicle Model in AVL Cruse-m Simulation Software

3.3. 3D Modelling for component placement

The initial dimensions for the chassis design were taken from the existing 2-wheeler. Reverse engineering is an excellent way to study the vehicle chassis in a detailed manner. It helps the researcher to detail the study of chassis (Figure 11).

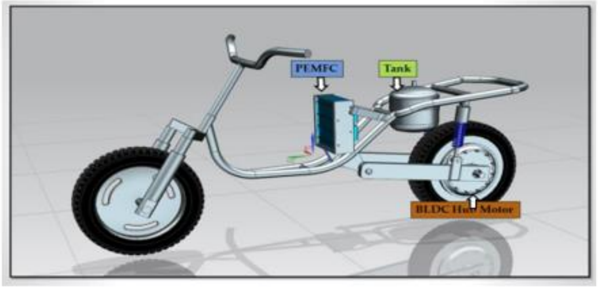


Figure 11. Unigraphics NX V8 Software of Two Wheeler

Other components dimensions are gathered by manual measuring using various measuring equipment's. A software called Unigraphics NX v8 software is used for the 3D modelling of 2-wheeler chassis with help of Table 1.

Table 1. Chassis dimension of FCEV

Wheel base (mm)	1230
Ground clearance (mm)	135
Height (mm)	1020
Width (mm)	640
F_W diameter (mm)	406.4
R_W diameter (mm)	406.4

4. Result and discussion

4.1. Experimental Results

4.1.1. Chassis Dynamometer Test for Full Load Acceleration

The dynamometer captures the mechanical energy output and performance. Both data acquisition systems are synchronized. The data was computed by means of video recording and decoding.

4.1.2. No load condition (Dynamometer Test)

The vehicle is fixed in chassis dynamometer and no passenger is occupied on the vehicle. The torque to the wheel has been provided by the dynamometer which possesses rolling inertia. The figure below shows the complete response of the vehicle for full throttle acceleration.

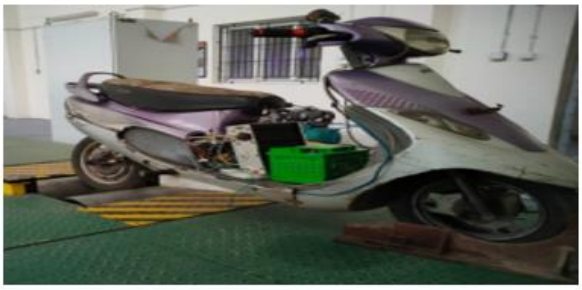


Figure 12. FC Vehicle on the Dynamometer

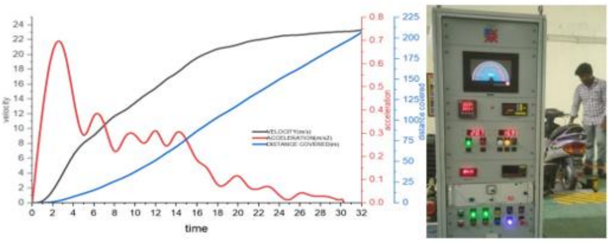


Figure 13. FC Tested by No Load condition on the dynamometer

Figures 12 & 13 for a no passenger condition, the graph is plotted. The throttle is completely accelerated in 1 second. During the test run, the vehicle reached its maximum speed of 0–23kmph within 32 seconds of time duration and it takes 207m of distance travelled.

4.1.3. Single Passenger Load Condition (Dynamometer Test)

The vehicle is loaded with single passenger load of 78 kg. The rolling resistance is induced by means of the roller in the dynamometer which possesses rolling inertia. The figure below shows the complete response of the vehicle for full throttle acceleration (Figure 14).

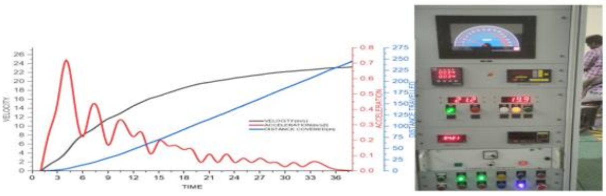


Figure 14. FC Tested by single passenger load condition on the dynamometer

For a single passenger condition, the graph is plotted. The throttle is completely accelerated in 1 second. During the test run, the vehicle reached its maximum speed of 0-23kmph within 38 seconds of time duration and it takes 241m of distance travelled.

4.2. Road test for full load acceleration

Since the dynamometer test results are found to deviating much, the vehicle is taken for the on-road testing to evaluate the dynamic performance of the fuel cell powered electric two-wheeler.

4.2.1. No load condition

The no load test condition is not physically possible in the real time but for the testing we followed here, the vehicle is put in centre stand and the wheel is support on the simple roller setup with very small rolling inertia. The throttle is completely accelerated in 1 second and the maximum speed of 0 - 24kmph is attained 18 seconds.

4.2.2. Single passenger load condition

The vehicle is loaded with single passenger load of 82 kg. The rolling resistance is induced by means of the road.

Iteration 1 and 2, the Figures 15 and 16. shows below the complete response of the vehicle for full throttle acceleration.

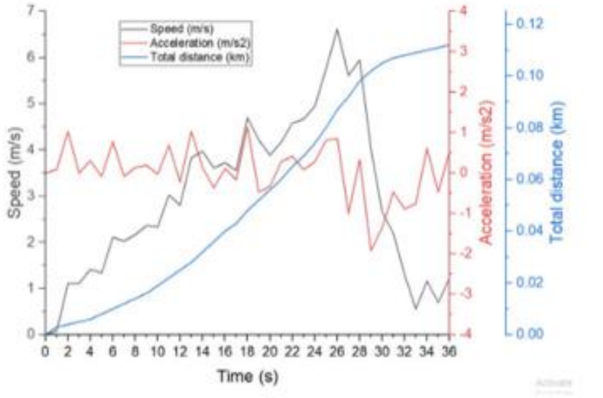


Figure 15. Iteration one

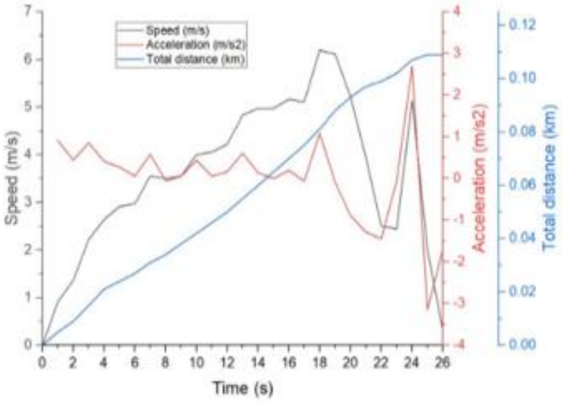


Figure 16. Iteration two

Figure 15 the throttle is completely accelerated in 1 second. The maximum speed attained is 0 - 24 km/h and distance travelled to reach the maximum speed is 85 m. The time taken to reach the maximum speed is 25 seconds. The maximum acceleration is found to be 1.2 m/s 2. Similarly, Figure 16 the throttle is completely accelerated in 1 second. The maximum speed attained is 0 - 24 km/h and distance travelled to reach the maximum speed is 84 m. The time taken to reach the maximum speed is 20 seconds. The maximum acceleration is found to be 1.15 m/s^2.

4.2.3. Congested urban route on road test (single passenger condition)

In the on-road test, a single passenger condition was taken. The weight of the passenger is 80 kg, respectively. The test route selected was inside the MIT campus. During the test, the hydrogen was filled up to 21 bars of 93. 23 litters are 41 taken.

Figure 17. On road range route(range1)

The Figure 17 is plotted with various measured data namely speed of the vehicle at instantaneous with respect to time as well as distance travelled during the test with exact GPS location are also measured. In a congested urban route, the vehicle has run up to 1.7km distance travelled with time duration of 551 seconds.

4.2.4. Urban route on road test (single passenger condition)

In on road test single passenger condition was taken. The weight of the passenger is 80kg respectively. The test route was classified into two types and it's inside the MIT campus. During the test the hydrogen was filled up to 21bar of 93.23 litters are taken.

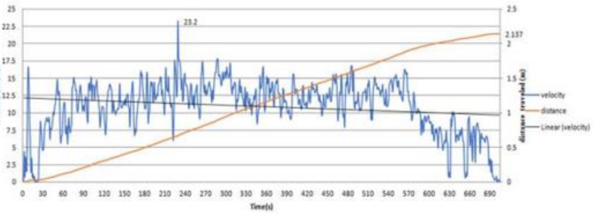


Figure 18. On road range route (range 2)

The Figure 18 is plotted with various measured data namely speed of the vehicle at instantaneous with respect to time as well as distance travelled during the test with exact GPS location are also measured. In an urban route the vehicle has run up to 2.23 Km travelled with the time duration of 672 seconds. By correlating both test we can conclude that 430 meters of distance were shortage in the urban. This is because of irregular pattern road pattern with more no of turnings in the route 1.

4.3. Study on performance characteristics using matlab simulation software

The MATLAB modelling was done to make a study on various parameters that affect the performance. The main parameters considered are Air/Fuel flow rate, temperature and pressure. The relation between the parameters and the power output of PEMFC was numerically designed in the Simulink model under various subsystems and the output graphs are plotted pressure. Various parameters are considered in the study.

4.4. Factors affecting fuel cell

4.4.1. Temperature

Figures 19 & 20 represented the fuel cell's efficiency is significantly impacted by operational temperature ranges. As the temperature of the stack rises, the fuel cell's voltage rises, and its efficiency varies in a manner similar to that. As temperature and pressure rise, the proton exchange membrane fuel cell's performance gets better. Because the increase in temperature and pressure has a relatively minimal impact on entropy. A fuel cell will work better and more consistently if there is less chance of entropy. As thermal energy is raised, a proton exchange membrane fuel cell's overall performance including current and voltage improves.

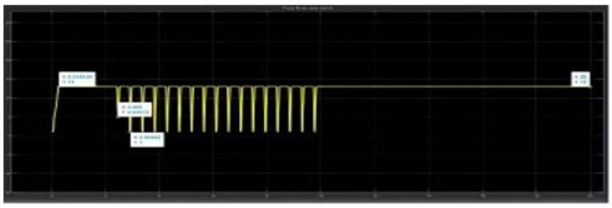


Figure 19. Time vs Fuel Flow Rate (T=40˚ C)

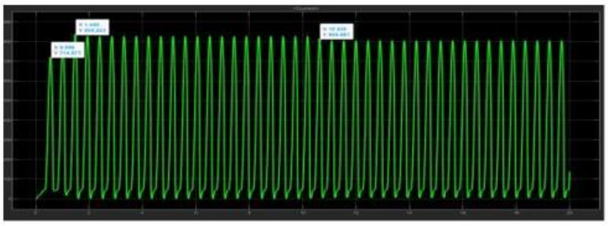


Figure 20. Temperature with efficiency (T=40˚ C)

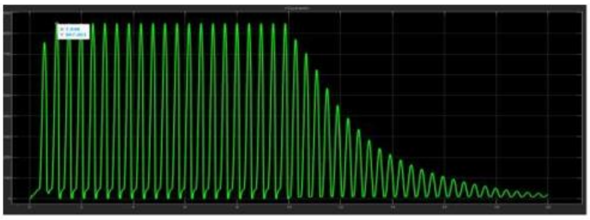


Figure 21. Pressure (2 bar) vs efficiency.

4.4.2. Pressure

At 1 bar pressure the stack efficiency reaches more than 30% and falls to 20%. After some duration, efficiency the efficiency does not exceed 10%. This is brought on by a decline in the fuel cell stack's hydrogen and oxygen reaction rate. At 2 bar pressure the stack efficiency reaches more than 60%. As the fuel cell stack's pressure rises, the interaction between hydrogen and oxygen intensifies, increasing the efficiency of the stack. Finally, it is observed that increases in pressure increases efficiency at certain level.

Figure 21 shown us the Current produced at the pressure 1 bar of the stack is 6.6A. Reaction of the Hydrogen and oxygen influences the current and voltage produced in the fuel cell. Current produced increases approximately up to 8.7A when pressure is increased to 2 bar. This is due to high reaction rate between Hydrogen and Oxygen. Hence it is observed that increase in pressure increases current. There is a slight change in the stack's cell voltage when the fuel cell stack's pressure rises. The voltage produced in the stack is seen to only vary little when the pressure of the stack is between 1 bar and 2 bar. In general, the effect of a voltage increase becomes less significant as operating pressure for proton exchange fuel cells rises above 4 bar because of problems with mass transport.

4.4.3. Oxygen

Figure 22 shown us the lowest continuous load point, stack efficiency is maximum at 55.2%; typically, larger mass flow raises stack voltage and efficiency. The maximum stack efficiency according to graph for oxygen concentration of 25% is about 45.5%. and for 30 % is about 45.1 %. negligible decrease in the efficiency when the concentration is high. So, while increasing oxygen level percentage the current is decreased at minimal level further with slight changes. The voltage and oxygen consumption are 46.0 v for the concentration of 25 % and 45.92% for the 30%.

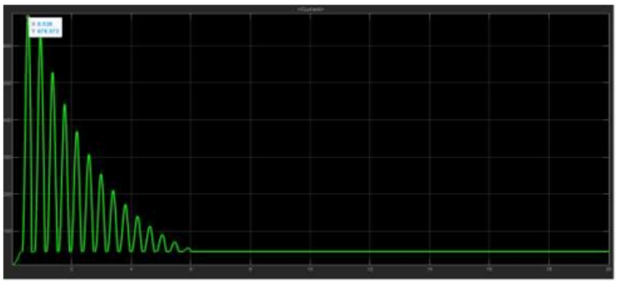


Figure 22. Oxygen flow % vs efficiency

4.4.4. Power train of FCEV

The theoretical calculation results of fuel cell electric vehicle were founded by using standard formulas, as shown in Table 2.

Table 2. Theoretical calculated values

S. No	PARAMETER	VALUES
1	rolling resistance	25.016 N
2	aerodynamic resistance	23.10 N
3	gradient resistance	0 N
4	acceleration force	0.7 m/s^2
5	required torque at wheel	14.28 Nm
6	required speed at wheel	520 RPM
7	power requirements	473 Watts
8	total resistance	186.916 N

5. Conclusion

The PEM fuel cell was designed and simulated in MATLAB, SIMULINK and simulating with various parameters showed that the fuel has the maximum efficiency when operating temperature, operating pressures are higher than the nominal operating conditions, but under these conditions the heat released by the fuel cell tends to be higher. The analysis of the various parameters on the fuel cell is found out to be that, the increase in pressure helps in increase in the stack efficiency and the voltage, current generation. The increase in temperature of the system seems to be increasing the quantity of the production but in such case of practical working this might heat up the system. Also, when the temperature utilized under Automobile applications must play a major role as any mechanical failure might lead to a severe mishap. The third Parameter of Oxygen has almost very low impact on the fuel cell as it is dependent on the hydrogen here, because only when hydrogen and oxygen react with each other the proper reaction occurs and the required power is generated.

The Mechanical Loading conditions are deeply analysed and we can infer from that, that the fuel flow rate increases with increasing the load and this is because more fuel is needed to produce more power and the peaks and dips are a reason of the saturation of the electricity generation at the point. The Oxygen Consumption also increases with increase in loading as the reaction between the Fuel and Oxygen give the power output so increasing the load increases the consumption of the oxygen. Also, the maximum of Fuel and Oxygen Consumption are observed when the load is increased at certain conditions.1KW stack is enough for power light weight delivery vehicle at the maximum speed of 28.8km/hr. In simulation 9.89 g of H2 is consumed to cover 569m in 108 s at maximum speed of 28.8km/hr.

FC bike would be the better option for conventional motorbike in urban area to be zero pollution in some extent and this could bring maximum range if in case fuel get empty, we can refill it with in some minutes. FC bike will competition with the IC engine vehicle for a longer distance run of the vehicle. As well as it will be a zero-emission vehicle.

Conflict of Interest

The authors have no conflicts of interest to disclose

Funding

No funding was received.

Future work

- Range extension of the 2-wheeler by increasing hydrogen storage capacity.
- Installing the safety equipment like hydrogen leakage detector sensor, pressure regulator, and automatic safety value.
- Competing it with internal combustion engine powered hybrid 2-wheeler

Design of recharging circuit for the battery which is used as a primary source for FC controller during the fuel cell is not in use.

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Nomenclature

S. No	Nomenclature	Description
1	PEMFC	Proton Exchange Membrane Fuel Cell
2	H2	Hydrogen
3	KW	Kilo watt
4	m	Meter
5	IC	Internal Combustion Engine
6	Km	Kilo meter
7	h	hour
8	S	Seconds
9	A	Amps
10	V	Voltage
11	DC	Direct Current
12	BLDC	Brush Less Direct Current
13	FC	Fuel Cell
14	MCB	Miniature Circuit Braker
15	Kg	Kilo gram
16	kmph	Kilo meter per hour

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